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Posterior tympanotomy versus endomeatal approach (EMA)

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Summary

The usual technique for cochlear implantation (CI) involves an antromastoidectomy and a posterior tympanotomy (PT) through the facial recess (1). The endomeatal approach (EMA) is a surgical technique that uses a direct approach through two natural orifices: the external auditory canal (EAC) and the round window (RW) (18, 19).

The aim is to describe the advantages of this approach; not only in conventional cochlear implant surgery, but in all those cases in which the posterior tympanotomy approach is difficult to perform.

The groove

EMA requires making a bony EAC groove for electrode lead (EL) lodging, in order to avoid contact between the skin and the EL that could lead to its extrusion .

A safe anatomic area to perform the groove with no risk for adjacent structures like facial nerve, chorda tympani, eardrum and ossicular chain were studied in Temporal bone Lab, and finally established with these landmarks: the incus and pyramidal process in the inner EAC side, and the outer border of tympano-squamous suture in the outer side. This groove placement is also on line with the axis of the more basal segment of scala tympani (ST), so the EL does not suffer any degree of bending after it is finally positioned in the ST.Fig.1

From the pyramidal process in up, there is enough room to drill a groove with a 0.5 mm cutting burr. An overhang is left in the superior groove's edge, in order to retain the electrode lead and avoid its contact with the EAC skin,therefore preventing extrusion.

1 mm wide and 2 mm depth is enough to cross the fallopian canal at a safe distance and lodge the EL. The pyramid level is the best place for the following reasons:

- a safe distance to FN even in infants;

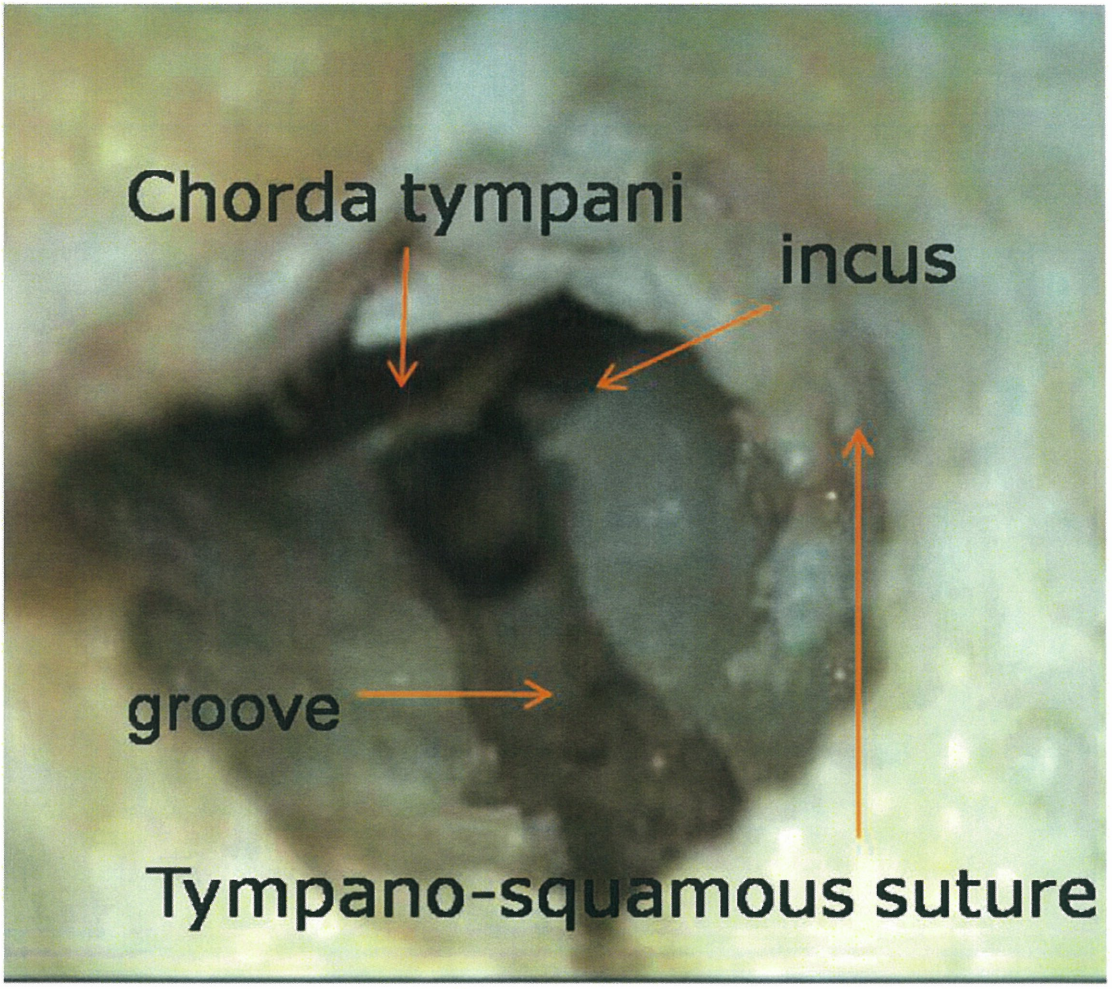

Fig.1 Groove anatomical landmarks

- good direct control of fallopian canal, visible at oval window;
- good position for electrode insertion in the plane described before;
- EL does not cross over the incus process in its way to the RW.

An anterior tympanotomy (stapedectomy- like) is needed in the first surgical stage through an autostatic ear speculum,to start the groove.In the second stage a retroauricular incision is performed,to extend the groove up to the mastoid surface and a small flat mastoid cavity (2cm wide, and 3mm depth) anterior to the well,is performed to lodge the wire excess.In the third stage,after RW electrode array (EA) insertion ,the groove is obturated with bone patè ,and the tymapanometal flap is replaced.

Rw optimal insertion plane inherent to ema

The safest site for positioning of the electrode array is the floor of the scala tympani(21). The projection of the axis of the basal spira passes between the posterior border of the oval window and the pyramidal process, and inferiorly by the internal aspect of the crista fenestra.Therefore,in order to avoid damage to the neurosensory structures, the direction of an optimal imaginary insertion plane must be from postero-

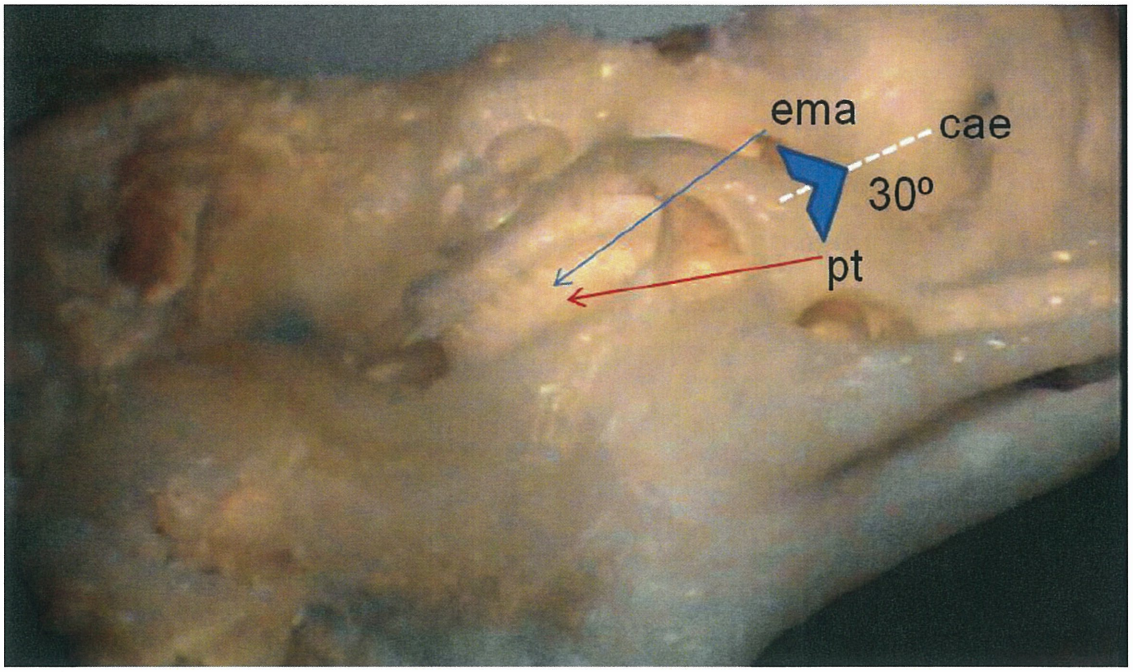

Fig.2 EMA optimal insertion plane (blue line)

superior to antero-inferior .EMA insertion plane is 30º more anterior and 15º superior ,compared with PT. Fig.2

Modified ema technique for pediatric surgery.(Emap)

In children the mastoid fossa (anterior well) is replaced by a deeper mastoid cavity that requires thinning of the posterior wall of the EAC in its external 2/3rds ,but without opening the mastoid antrum (17).

The external portion of the groove is communicated with the mastoid cavity, transforming the groove in a narrow open cleft that will allow the passage of the electrode array into the bottom of the cavity. The groove is limited to the internal third of the osseous EAC, thus avoiding tension and displacement during the development of the osseous canal.

The cleft and short groove are obturated with bone patè. The excess cable adopts a position that is similar to the transmastoid approach, but limiting the drilling of healthy tissues without exposing the mastoid antrum. Fig.3

Posterior tympanotomy vs ema round window atraumatic insertion.

Regardless of the surgical approach, cochlear implant surgery is subjected to limited anatomical spaces. In the case of posterior tympanotomy, the opening of the facial recess is not always sufficient in order to expose the round window adequately. At times extensive drilling is required (3).EMA uses the EAC which is anatomically less

limited than posterior tympanotomy. The natural access to the area of the windows is via the EAC. That is why stapes surgery is done by an endomeatal , and not a posterior tympanotomy approach. Exposure of the round window is always possible

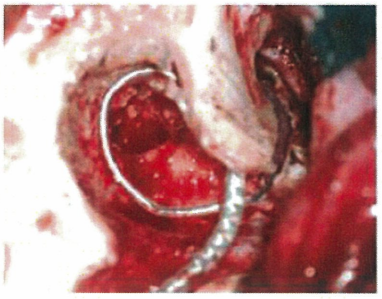

Fig.3 EMAP. Pediatric mastoidectomy without antrostomy. Modified technique for Pediatric surgery

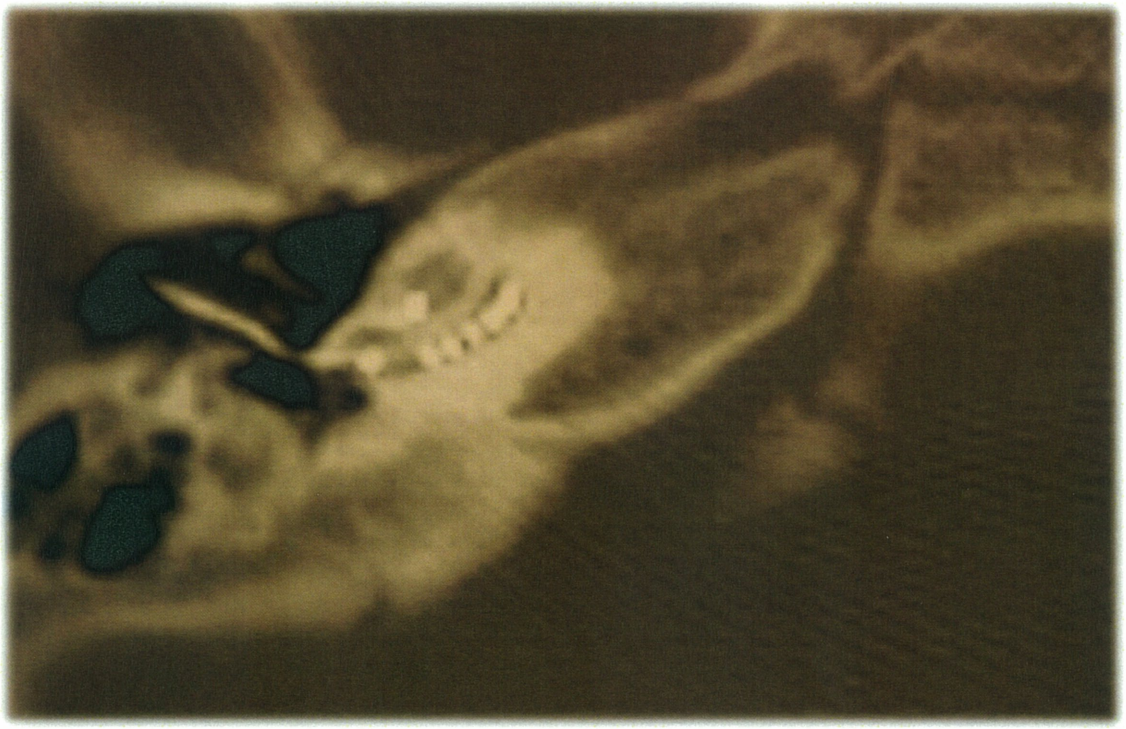

Fig.4 EMA Round Window EA insertion

through the endomeatal approach. This is not the case with posterior tympanotomy. Fig.4

Posterior tympanotomy vs ema in prominent lateral sinus

Posterior tympanotomy is not feasible in cases of a low tegmen or a prominent lateral sinus. In these cases removal of the posterior wall ,and closure of the EAC is required.EMA only needs to lower the posterior wall as much as needed for a correct angle of insertion,without any risk for facial nerve and to remove totally the RW overhang in a safe manner,because there is no significant histological structure at this anatomical point.

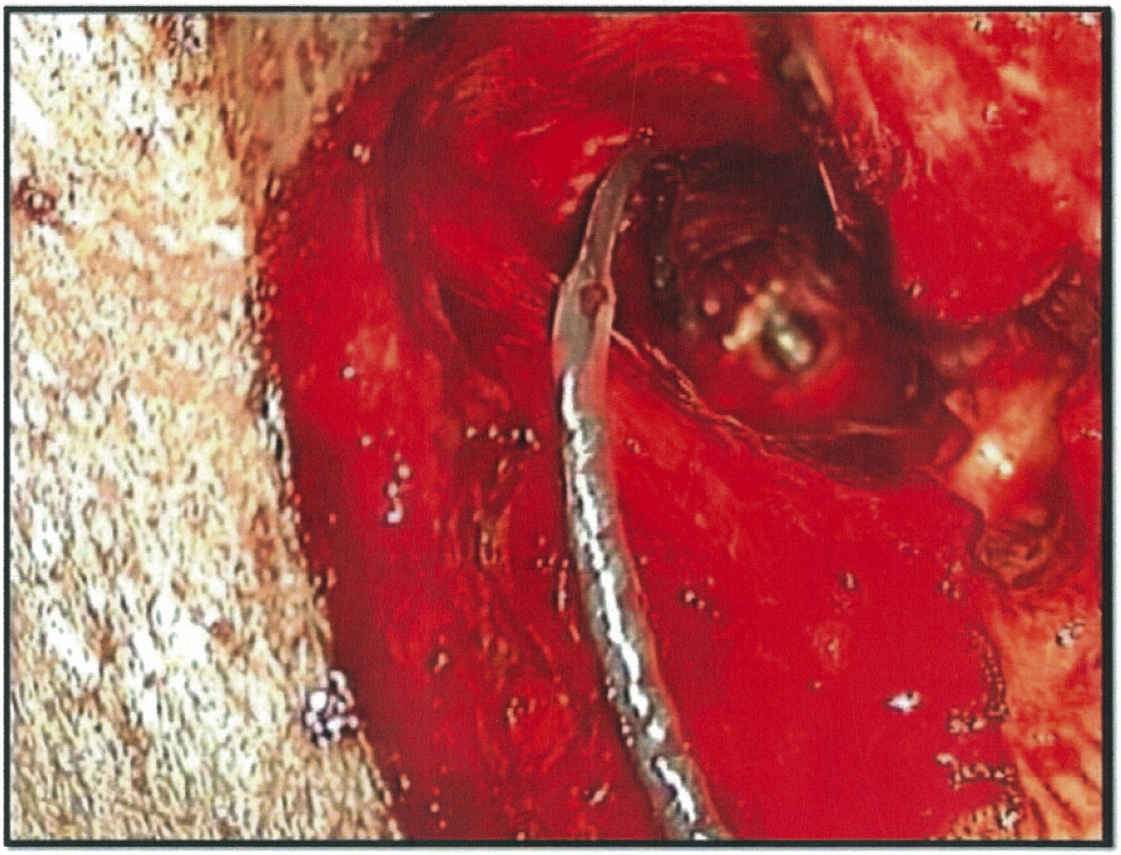

Fig.5 EMA Double cochleostomy.Basal turn insertion and medial turn control

Posterior tympanotomy vs ema in ossified cochleas.

The anatomical location of the cochlea is anterior to the posterior wall of the EAC. EMA allows to maintain this wall ,and to have access to any area in the cochlear turns. The maintenance of the spaces that are free of ossification allows adequate stimulation. An alternative that is possible with EMA is to do a double cochleostomy ,with the intention of maintaining these spaces and confirm an adequate insertion.

Sistematization of the technique.

a. Partial ossification .**Double cochleostomy**.

Usually the ossification is located in the basal turn, near the round window.

In these cases the drilling is initiated from the round window in an anterior - inferior direction towards the beginning of the turn ,of the basal turn. It is possible to find non ossified spaces in this area, and to perform a cochleostomy. A second cochleostomy can be done with a 1 mm. burr at the side of the first one, under the cochleariform process, at the level of the medial turn (turn).

If a basal cochleostomy can be done, the electrode guide is inserted and then checked through the medial cochleostomy, thus making sure that the electrodes are correctly positioned.This maneuver is particularly useful when intraoperative radiology is not available. Fig.5

If the insertion of the electrode guide would not be posible from the basal turn, a reversed insertion can be done from the cochleostomy of the medial turn, in

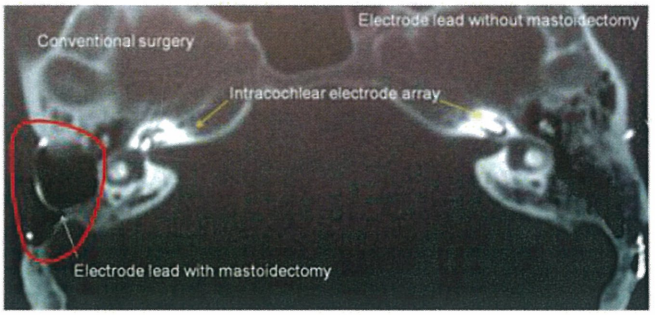

Fig.6 Bilateral cochlear implantation. Comparing EMA and posterior tympanotomy. Note the mastoidectomy in PT compared to mastoid preservation with EMA.

direction towards the round window. It is not necessary to sacrifice the ossicular chain which serves as an anatomical landmark. Double cochleostomy allows a safe insertion when it is done from the basal turn.Magnetic resonance imaging is essential in these cases.

b. Total ossification.

EMA allows a circunmodiolar technique in order to completely expose the basal turn. This implies the elimination of the medial turn and apical turns, conserving the posterior wall of the EAC. The ossicular chain must be sacrificed in order to place the tympano-meatal flap as anterior as possible. The tensor tympani muscle is sectioned as well as the malleus head maintaining its handle, since this allows stabilization of the tympanic membrane once the flap has been replaced.

Posterior tympanotomy with double array insertion, is a blind technique that does not control the final end of the surgical instruments,and can cause internal carotid artery damage (15), as an almost fatal complication,not only for bleeding but also for Central Nervous System consequences.Internal carotid artery has a very close anatomical relation with the basal spira.EMA allows a total and safe control of the whole cochlea, even in cases where a complete dissection of the basal turn is required,something that is not possible through PT.

Posterior tympanotomy vs ema in temporal bone malformations.

The potential benefit of EMA is maximized when there are malformations with a bifurcated facial nerve ,or a facial nerve with an anomalous tract.

In these cases the risk of damaging the nerve by a posterior tympanotomy approach is high,whereas in the approach by the ear canal the risk is significantly diminished. In congenital malformations identified with an adequate CAT scan, a cochleostomy via an endomeatal approach can be done without the risk of damaging the facial nerve.

Posterior tympanotomy vs ema in previous mastoidectomy

In those cases it is not convenient to have the cochlear implant in a position that is related to the previous procedure (eg.meningocele, fistula, radical surgery, etc.)

EMA allows to be less concerned with the status of the mastoid, especially in

cases of radical cavities. EMA avoids the mastoid bone and respect the results of the previous surgery. Depending on the surgeon´s surgical habits ,it can also be simpler to perform in ears without previous procedures.

a. Incision.

A superior and posterior extended endopreaural incision is done (Lempert I-II). The extension will depend on the implant that is being used ,and it should be done in one plain.

b. Groove.

The endomeatal groove is extended by drilling the superior wall of the EAC until reaching the external surface of the temporal squama. It is a safe anatomical area and the dimensions of the groove are similar to those that are done in the mastoid (1mm wide by 2 mm deep). It is not necessary to do any extra drilling for the excess cable, because the distance that the electrode guide has to travel is longer due to the abscense of a mastoidectomy. The electrode guide is placed subperiostically, as if it were a reference electrode.

c. Round Window.

EMA with a Lempert (endopreaural) incision allows the use of an autostatic speculum at the moment of insertion of the electrodes ,and this facilitates control in the round window.

d. Insertion.

The electrode array should be placed first, and then the receptor- stimulator (RS). Otherwise the electrode array can end up being short during the insertion maneuvers. The RS is placed under the inferior lip of the skin incision and is introduced until the exit of the electrode guide, so that the receiver ends up completely covered by the musculo-cutaneous plane ,but without placing it in its bony bed yet. The electrode array is then inserted through the autostatic speculum, and once it is done the speculum is withdrawn. Then, the RS is placed in its definite position.

e. Positioning of the RS.

The RS will have a more horizontal position compared to the retroauricular approach because the electrode guide must be directed to the superior wall of the EAC, and not to the facial recess.

f. Fixation.

Fibrin glue can be used in the middle ear and the groove and at the level of the RS. It helps to fix the implant ,and avoids unwanted displacements during the surgical maneuvers ,at the same time that it provides isolation. The surgical stages are similar to those of EMA with retroauricular incision.

Posterior tympanotomy is not possible in this specific case,where the mastoid is filled with fibrotic tissue, there is no facial nerve anatomical landmarks and the risk to contaminate the CI surgery and tear the dura mater is very high (Fistula).EMA allows to positionate the electrode array in all cases with previous mastoidectomy,respecting the previous surgery and without cavity reconstruction.Posterior tympanotomy is not able to conduct surgery in that manner.

Pt vs ema simoultaneous bilateral pediatric ci

Mastoid surgery in a child ,is done in a soft cortical bone and non neumatized spongy bone tissue that usually bleeds,because that,it is important to reduce bleeding

and surgical time.PT is a transmastoid approach that destroy the MACS (mastoid air cell system) with their consequences.(20,22,23)

EMA preserves the MACS without the risk of mastoid bleeding and hipovolemia ,and at the same time reduce surgical time.

Conclusions

Posterior tympanotomy is not a surgical approach designed for CI.As a matter of fact,CI surgery did not exist at that time.PT was designed for chronic middle ear surgery to explore the tympanic cavity with some limits,as it is not possible to reach the sinus tympani and the supratubal recess, that indeed must be explored in cholesteatoma surgery. EMA is able to explore the whole tympanic cavity.

CI is the most exciting advance in ear surgery,and surgeons must offer something more than an ancient surgical procedure (Zaufal E.Tecnik der trepanationdes Proc. Mastoid,1893).EMA is an actual surgical technique.

PT is not able to preserve healthy tissues and destroy the MACS (Mastoid Air Cell System) that helps to maintains middle ear pressure and is a significant factor in EAS.EMA preserves the MACS .(20,22,23)Fig.6

PT use the facial nerve as an anatomical landmark,with facial nerve complications (8) EMA is a safe facial nerve surgery.

PT can have complications due to sigmoid sinus skeletonization (bleeding),dura mater exposure (cerebrospinal fluid leak).EMA avoid these complications and saves surgical time.

PT does not have a RW correct angle of insertion,and needs to sacrifice chorda tympani and sometimes to remove the buttress (3).EMA has an optimal RW insertion plane, and preserves all functional structures.(18)

PT only have disadvantages in normal cases vs EMA,and in difficult cases (prominent sinus,ossified cochleas,temporal bone malformartions,small mastoid bone,previous mastoidectomy,simoultaneous pediatric bilateral CI ,etc) is not even possible to carry out, without taking much more risks, as compared with EMA.

EMA for CI is the result of more than 30 years of experience with this surgical technique.As the same manner patients must be selected for a CI, with a correct indication,surgical approaches must be also selected according with a correct indication.CI was not an indication for PT,but for timpanic cavity access.

CI surgery is not a pathology,is an electronic device that solves a pathology, and it does not matter how it is positioned in the temporal bone, meanwhile it works properly and be stable in time.

EMA can replace PT with much more advantages,depending also in surgeons surgical habits.EMA can be practice by those surgeons that can consider it an easy(natural orifices access),safe (no facial nerve risk),fast (no PT-Mastoidectomy) and soft (correct angle of insertion) surgical procedure.

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